

Range Education in the 21st Century: Striking the Balance to Maintain a Relevant Profession

Laurie B. Abbott,¹ Karen L. Launchbaugh,² and Susan Edinger-Marshall³

Authors are ¹Associate Professor, Department of Animal and Range Sciences, New Mexico State University, Las Cruces, NM 88003, USA; ²Professor and Director, Rangeland Center, University of Idaho, Moscow, ID 83844, USA; and ³Professor, Forestry and Wildland Resources Department, Humboldt State University, Arcata, CA 95521, USA.

Abstract

Range science education programs strive to keep pace with the changing needs of the range profession and to ensure that range graduates are knowledgeable, skilled, and able to address contemporary, complex problems unique to rangelands. Today, range education programs face many challenges in our ability to meet the demands and needs of our profession and society. First, our capacity to meet the demands for range science graduates has been diminished by 1) elimination or restructuring of academic rangeland science programs, 2) reduced numbers of range-trained faculty teaching rangeland courses, and 3) limited public awareness of degrees and careers in rangeland science and management. Second, range education programs are challenged to strike a balance between retaining traditional basics and modernizing curriculum to include contemporary concepts and technologies. Third, range science graduates need to understand the current social, political, and economic context of resource management, including global change issues that are of paramount concern to society. We propose multiple approaches to meet these challenges: 1) perform needs assessments with diverse stakeholders to ensure that range education programs are relevant to society's needs and address the future of the profession; 2) find innovative approaches to strike the educational balance between fundamental concepts, practical field experiences, and mastery of technical and interpersonal skills; 3) collaborate across institutional boundaries to share educational resources and incorporate course formats that meet the diverse needs of today's students; 4) examine and align professional qualifications, educational standards, and curriculum by defining learning outcomes and core competencies needed by well-trained range professionals; and 5) communicate the unique features of the rangeland profession that solidify its position among the disciplinary pillars of natural resource science and management.

Resumen

Programas de educación en la ciencia de pastizales se esfuerzan por mantener el ritmo con el cambio en las necesidades de la profesión del manejo de pastizales, y para asegurarse de que los estudiantes al graduarse cuentan con los conocimientos, habilidades y que sean capaces de abordar problemas contemporáneos y complejos, únicos de los pastizales. Hoy en día, los programas de educación en manejo de pastizales se encuentran ante muchos retos en nuestra habilidad para cumplir con las demandas de las necesidades de nuestra profesión y sociedad. Primero, nuestra capacidad para cumplir las demandas de los estudiantes graduados de manejo de pastizales han disminuido por: 1) la eliminación o reestructura de los programas académicos del manejo de pastizales, 2) reducción del número de cursos en pastizales enseñados por profesores entrenados en el área de manejo de pastizales, y 3) una conciencia pública limitada de los grados y carreras relacionadas con el manejo y la ciencia de pastizales. Segundo, los programas de educación en manejo de pastizales tienen el reto de alcanzar un balance entre retener la tradición básica y la modernización de la curricula para incluir conceptos y tecnologías contemporáneas. Tercero, graduados de programas de manejo de pastizales necesitan entender el contexto social, político y económico actual del manejo de recursos, incluyendo cuestiones de cambio global que son de suma importancia para la sociedad. Nosotros proponemos múltiples acercamientos para cumplir con estos retos: 1) realizar evaluaciones de las necesidades con las diversas partes interesadas para asegurar la educación de los programas de manejo de pastizales son relevantes para las necesidades de la sociedad y abordar el futuro de la profesión; 2) buscar formas innovadoras para alcanzar un balance educacional entre los conceptos fundamentales, experiencias de prácticas de campo y el dominio de habilidades técnicas e interpersonales; 3) colaborar a través de las fronteras institucionales para compartir recursos educacionales e incorporar cursos con formatos que satisfagan las necesidades de los estudiantes de hoy; 4) examinar y adaptar las credenciales profesionales, estándares de la educación y curricular mediante la definición de los resultados del aprendizaje y competencias básicas necesarias por los profesionales bien entrenados de manejo de pastizales; y 5) comunicar las características únicas de la profesión de manejo de pastizales que solidifiquen su posición entre los pilares de la disciplina de las ciencias naturales y el manejo.

Key Words: core knowledge, curriculum, range science and management, teaching, undergraduate education

This work was supported by a USDA Higher Education Challenge grant titled "Repositioning Rangeland Education for a Changing World" (CRIS Number 0222937).

Correspondence: L. B. Abbott, New Mexico State University, PO Box 30003, MSC 3-1, Las Cruces, NM 88003, USA. Email: labbott@nmsu.edu

Manuscript received 11 August 2011; manuscript accepted 4 June 2012.

INTRODUCTION

Since its inception, the rangeland profession has embraced the challenge to produce a solid body of science that is relevant to rangeland management. Rangeland ecology and management is an inherently interdisciplinary field that requires the integration

of plant, animal, soil, wildlife, and environmental sciences, hydrology, economics, policy, and sociology. Range professionals are expected to possess range-specific technical proficiencies and interpersonal skills, such as leadership, collaboration, and communication (Thurrow et al. 2007).

Twenty-three North American universities and colleges currently offer degrees in rangeland ecology, science, or management; an additional 23 colleges and universities in the United States, Canada, and Mexico offer range science and management courses at the undergraduate level (SRM 2011). These programs offer diverse options for students because of differences in program sizes and regional differences reflecting issues of local relevance, such as landownership patterns and the people relying on the landscapes.

As educators, our overarching goal is to ensure that range professionals are properly educated and trained to address complex problems unique to rangelands (Sayre et al. in this issue). We assert that rangeland science and management is sufficiently distinct from other academic disciplines to be sustained despite trends in higher education toward elimination of small academic programs. In the remainder of this article, we discuss 1) challenges to range education programs today, 2) adjusting our educational approach to meet the needs of the profession, 3) meeting societal needs and desires, and 4) strategies to make range education balanced, resilient, and credible.

CURRENT CHALLENGES IN RANGE SCIENCE EDUCATION

What Factors Limit the Effectiveness of Range Education Programs?

Career opportunities for students with rangeland baccalaureate degrees are robust among federal agencies and the private sector. Growing public concern over maintaining healthy rangelands and the ecological services they provide ensures a need for rangeland graduates well into the future (Cowling et al. 2008). Rangeland management specialists are a small but critical group within natural resources disciplines. Based on a combination of US Bureau of Labor Statistics and US Department of Education data, the employment picture is much brighter for graduates with degrees in range or soil science seeking conservation scientist positions (range managers and soil conservationists) relative to graduates seeking positions as foresters or wildlife biologists (Table 1).

The federal workforce of conservation scientists, including rangeland specialists, is projected to increase in the coming decade (BLS 2009), and this demand will be augmented by

anticipated retirement of rangeland professionals in the next decade (OPM 2008). Based on a conservative assessment of these trends, we foresee an annual demand for about 385 new range professionals during the decade ending in 2018. Although the number of students who graduated annually with baccalaureate degrees in rangeland ecology and management increased in the past decade, from $114 \cdot \text{yr}^{-1}$ between 1997 and 2001 to 147 in 2006 (Schacht and McInnis 2003; NCES 2008), range programs are graduating roughly 30–40% of the number of new range professionals needed annually by federal land management agencies. These estimates are quite conservative since they do not account for range positions with state agencies, tribal governments, or the private sector. If the potential shortage of well-trained range graduates is not met, a significant number of range management positions may be filled by individuals with inadequate knowledge and skills to properly manage rangelands (Heady 1999; McClaran 2000).

Range education programs face further declines in capacity resulting from three major causes: 1) elimination or restructuring of range programs, 2) reduced numbers of range-trained faculty teaching rangeland courses, and 3) limited public awareness of careers in range science and management. University support for rangeland programs has been eroding for several decades (McClaran 2000), and many academic institutions have responded to shrinking budgets by eliminating or merging programs with small enrollments. Of 22 academic programs in the United States offering baccalaureate degrees that prepare students for rangeland careers (SRM 2011), only five or six of these programs consistently graduate more than 10 students annually, the minimum number of graduates set by most universities for program viability (Schacht and McInnis 2003; Thomas Bedell, unpublished data, 2010).

University administrators have strived to increase perceived efficiencies by merging natural resources programs into interdisciplinary departments. In the 1980s, seven university departments were stand-alone range departments; today, no stand-alone range departments remain, and only five departments contain the term “range” or “rangeland” in their department names. As a result, existing rangeland expertise may be sequestered in departments named Wildland Resources, Ecosystem Science and Management, or Plant and Wildlife Sciences. Furthermore, when rangeland educators are housed in different departments and/or colleges within an institution, loss of academic cohesion creates challenges for remaining range faculty to maintain strong rangeland degree programs. Proponents of these mergers contend that larger interdisciplinary units offer greater opportunities to integrate and diversify science and education and to immerse students in interdisciplinary learning environments and thus are better able to

Table 1. Comparison of annual availability of positions in selected natural resource careers and baccalaureate degrees granted.

Career	Bureau of Labor Statistics, annual positions available (based on projections for 2008–2018)	Bachelor's degrees granted (2007–2008), Digest of Educational Statistics	Ratio of positions available to degrees granted
Conservation scientists (range managers and soil conservationists)	220	271	0.81
Foresters	140	974	0.15
Zoologists and wildlife biologists	250	1 056	0.24

address the complex contemporary challenges facing resource management (Matter and Steidl 2000). However, natural resources fields are distinguished by fundamental characteristics unique to each field. For example, while the disciplines of range management and forestry certainly share some fundamental principles of ecology and management, these systems are distinctly different in terms of their structure, function, and response to management. Range professionals and foresters require different knowledge and skills sets; for example, plant cover, density, and production are important concepts in both fields, yet commonly applied methods of measuring these attributes are quite different for the two disciplines. It is essential that students pursuing rangeland careers are properly educated and trained, and there is a growing concern over the depth with which range-specific skills and knowledge are being addressed in multidisciplinary departments, degrees, and courses (McClaran 2000). A more subtle concern with these mergers is the loss of name recognition for the major and profession.

The educational background and expertise of faculty teaching range courses is shifting. Increasingly, faculty teaching range courses lack educational backgrounds in range science and management; between 2005 to 2010, the percentage of faculty in rangeland programs who do not possess any degrees in range science increased from ~10% to ~15% (Thomas Bedell, unpublished data, 2010). As baseline state and federal funding sources wane, research funding is increasingly dependent on competitive grants that tend to support basic research more than applied science (Sherwood 2004; Thurow et al. 2007). Hiring criteria favoring individuals with the ability to garner competitive grants in basic research may be restructuring the composition of faculty expertise in range programs. Changing faculty demographics could ultimately redirect educational focus away from applied aspects of rangeland science and consequently transform the focus and depth of discipline-specific instruction and/or diminish students' appreciation for science-based management (Millenbah and Wolter 2009).

Finally, limited public awareness and pervasive misconceptions about rangelands continue to plague our profession, and efforts to advance range education may fall victim to these invalid perceptions. Most rangeland educators, scientists, and managers realize that a substantial proportion of the general public are unfamiliar with rangelands and are ignorant of the principles that underlie their management. Some confusion simply results from terminology. Most people can conjure up mental images of grasslands, prairies, shrublands, woodlands, or deserts but would rarely apply the term "rangeland" to these landscapes (e.g., Heinz Center 2008). Furthermore, many people equate rangeland management with livestock management, with little appreciation for the vast array of resources and ecosystem services provided by rangelands or for the competence of range professionals to sustainably manage rangeland ecosystems (Malechek and Call 1999; Schacht and McInnis 2003; Maczko and Hiding 2008).

Lack of awareness and misconceptions about rangelands and range careers reduce the ability of rangeland education programs to meet the demand for graduates because students do not pursue degrees or careers that are unknown to them. Students are often attracted to more charismatic degrees, such

as wildlife management, veterinary science, forestry, or conservation biology (Schacht and McInnis 2003; NRC 2009). Furthermore, students from urban and suburban backgrounds may perceive rangeland careers as agricultural or livestock focused rather than being centered on ecology and conservation (Knight 1999; Taylor 2003). Finally, educational administrators do not defend and maintain degree programs or faculty positions that they do not perceive as important and relevant. Despite years of discussion and debate, identity remains an underlying and unresolved issue in our profession (Kreuter 2001; Thurow et al. 2007).

Are We Meeting Changing Educational Demands of the Profession?

As the profession evolves, range education programs are challenged to strike a balance between retaining traditional basics and modernizing curriculum to include contemporary concepts and technologies. Historically, philosophical debates about curriculum have centered on the dichotomy contrasting the importance of conceptual knowledge versus mastery of practical field skills (Smith 1952; Heady 1961, 1999; Lehman 1964; Malechek 1992; Nicholson 1992; McClaran 2000; Thurow et al. 2007). Despite widespread recognition that students need to develop proficiency with range-specific tools and techniques essential to the art and science of range management, a variety of factors tend to shift the balance toward teaching courses centered on fundamental principles and concepts.

The past decade has witnessed nearly exponential increases in the use of computer-based technology, to the point that today's students and young professionals have difficulty envisioning how range science was accomplished before digital technology. Today's rangeland programs are challenged to provide access to modern equipment and computer-based technology to ensure student mastery of modern essentials such as GIS and advancements in rangeland monitoring and planning.

With or without technology, range students need to develop solid ecological understanding in real-world settings, develop the capacity to "read" ecosystem change and understand processes at landscape scales, and be able to detect and interpret patterns of vegetation and soil change, yet these skills are relatively weak among today's graduates (Heady 1999). This trend likely reflects less educational time spent in outdoor settings compared to several decades ago: stand-alone field courses, tours, and field camps were once a cornerstone of range programs but are quite rare in modern university curricula (Heady 1961; McClaran 2000). Maintaining the field components of curriculum is becoming increasingly difficult because of the expense and university requirements dedicated to competing core courses. As Heady (1999) cautioned, "We dare not forget that the tool to analyze data must not replace understanding the information."

Educational standards and professional expectations for rangeland ecology and management degrees are shaped by a variety of entities, including academic programs, the professional society, and federal agencies. Specifically, these degrees are shaped by 1) learning outcomes and assessment defined at the level of academic degree programs, 2) range education

program accreditation administered by the Society for Range Management (SRM), 3) certification programs administered by SRM (i.e., Certified Professional in Range Management and Certified Range Management Consultant programs), and 4) federal Office of Personnel Management (OPM) qualification standards for employment as rangeland managers with federal land management agencies (GS-0454 series). SRM accreditation encompasses a comprehensive evaluation of an academic program's quality and capabilities to prepare graduates for the range profession. In addition to specific standards related to curriculum, accreditation addresses qualifications of the faculty members, institutional support, evidence of program effectiveness, and advising and extracurricular professional development. Certification of individuals by SRM is awarded on the basis of documentation of educational preparation, professional experience, and written examination. The OPM standards require a degree in range management or related discipline and specify a suite of core range courses, related plant, animal, and soil courses, and resource management courses totaling 42 semester hours (OPM 2009). Given that numerous entities were concerned with the education of range professionals, the Range Science Education Council (RSEC) was established to promote high standards in range education and to facilitate discourse between educators, employers, and members of the range profession on issues pertaining to range education and employment standards (RSEC 2000).

University courses and curricula are strongly influenced by SRM accreditation guidelines and OPM standards (McClaran 2000). Guidelines and standards that adopt a "course list" approach are viewed as excessively inflexible and do not necessarily reflect knowledge, skills, and abilities needed by contemporary rangeland professionals (e.g., interpersonal skills including leadership, teamwork, conflict resolution, ethics, and sensitivity training; Box 1964; Malechek 1992; Nicholson 1992; Sowell 1997; Kreuter 2001). Evaluating the rigor of a rangeland degree program is further complicated because course titles alone may not directly reveal course content and learning outcomes.

Do Range Science Education Programs Anticipate Society's Needs and Demands?

Global issues such as climate change, food, water and energy security, biodiversity, and desertification are increasingly important to society and are among the largest challenges facing the range science profession (Taylor 2003; see also other articles in this issue). Local and regional concerns include open space and wildlife habitat, restoration, Native American sovereignty, conservation easements, family business succession, ranch enterprises, niche markets, multiple-use demands on public rangelands, energy development, rural crime, and border issues. Integration of new and emerging issues into existing curriculum represents a continual challenge to range educators yet is essential to ensure that today's graduates are well prepared to meet professional challenges in a changing world.

Understanding human desires and demands are fundamental to our profession: the very premise of managing resources stems from the fact that resources are used and appreciated by people. Range graduates are required to understand the social,

political, and economic context of resource management, including an ability to work with diverse people who hold diverse views and needs (Sowell 1997; Lopez et al. 2005). Furthermore, as the student population changes demographically and culturally, it is essential that rangeland educators recognize that our approaches to teaching may need to change to accommodate the needs of today's students (Millenbah and Wolter 2009).

FUTURE DIRECTIONS TO STRIKE THE BALANCE

Challenges facing range education are formidable, yet addressing these challenges is pivotal to ensuring that range professionals of the future remain at the forefront of rangeland management. We suggest the following approaches to address these educational challenges: 1) vigorously address the future of the profession by performing needs assessments with diverse stakeholders, 2) balance traditional course content with development of professional skills, 3) collaborate across institutional boundaries to share educational resources and develop alternative course formats to expand educational opportunities, 4) redefine standards and criteria for employment to reflect modern core competencies and professional expectations, and 5) communicate the unique features of the range profession that justify its continued, distinctive existence among natural resource disciplines.

Identifying Educational Needs

Range professionals and range educators have historically ensured and should continue to ensure that range science and management are relevant to society's values and expectations for rangelands (Kreuter and Schellenberg 2001). As perceptions of rangeland products, uses, and services become more diverse, ensuring that the profession's priorities align with societal values is increasingly complex and difficult to reconcile (Box 2001). Understanding society's perceptions and demands is critically important in the context of global change and expectations that management must be prepared to adapt accordingly (see other articles in this issue). Therefore, it is essential to vigorously address the future of the profession by performing needs assessments with a diversity of stakeholders who are aware of current and emerging issues. Through strategic interviews and discussions, we will gain unique insights about specific skills and knowledge that will be needed by tomorrow's range professionals (Taylor 2003). This process, initiated by a subgroup of RSEC representatives in 2011, will ensure that a broad representation of viewpoints and regional concerns will inform the restructuring of contemporary range education programs.

Articulating a Balanced Set of Core Competencies and Educational Objectives

Solid, relevant range education requires linking the traditional, technological, and scientific aspects with a deeper awareness of the human dimension. Curriculum development requires a pragmatic balance between extensively covering content and teaching the bare essentials of the discipline (McClaran 2000).

Certainly, educators need to keep their courses current by updating or adding new content as relevant topics emerge, especially if expanded educational standards include new subject matter. However, adding new content (modules or courses) requires careful balancing of curriculum and degree requirements. First, most undergraduate students share a reasonable desire to finish a baccalaureate degree in 5 yr or less (Smith 1952; Norton and Eastmond 1981; Schacht and McInnis 2003), and academic programs are typically expected to demonstrate that degree requirements can be satisfied in 4 yr. Second, adding new material often comes at the cost of dropping other content. Since faculty tend to enjoy a certain amount of flexibility in what and how they teach, content gaps may occur over time without apparent changes to the curriculum. Finally, essential range-centered content may be diminished or lost in restructuring of curricula during the merger of multidisciplinary programs.

We must find innovative ways to strike the balance, by providing students opportunities to gain knowledge, practical experience, and mastery of skills within rangeland degree programs. In addition to teaching content-specific knowledge and technical skills, a well-balanced curriculum needs to promote development and mastery of skills in oral and written communication, analytical and critical thinking, and interpersonal skills, such as leadership, team building, and conflict resolution, throughout the student's academic experience. Learning activities that build these less tangible skills must be incorporated into courses throughout the students' academic experience and not just reserved for senior and capstone courses. We encourage all faculty groups to identify core knowledge, competencies and skills sets, and educational outcomes that define a well-educated graduate of their program in rangeland science and conduct programmatic self-studies to ensure that their curriculum is designed to support the full suite of desired learning outcomes.

One final caveat about practical knowledge: at all costs, we must resist the temptation to reduce field experiences. One complaint frequently heard from employers is that today's graduates lack basic skills and practical knowledge learned in the field (Kienast and Scifres 1973; McClaran 2000; but see Sowell 1997). This may result in part from changing student demographics; the proportion of students from rural or agricultural backgrounds is declining relative to those from urban and suburban origins (Knight 1999; Thurow et al. 2007; Edinger-Marshall and Perry 2011). Providing field experiences is costly in terms of logistics support and faculty time. Yet field-savvy acumen is a distinguishing characteristic of natural resource professionals, and instilling this type of expertise not only is essential for the professional development of range graduates but also represents a "litmus test" necessary to establish credibility with stakeholders.

Expanding Educational Opportunities

As programs are eliminated or merged with other disciplines, reduced faculty numbers will require creative solutions to ensure that students have access to high-quality educational experiences despite institutional constraints. One solution is collaboration among range educators by pooling expertise across institutional boundaries to develop and fully share

educational materials following an open-source Internet cooperative model. For example, members of the RSEC are currently developing online learning modules, such as video-based virtual field trips, that will be accessible to students via the Internet and open-access teaching materials, including presentations and activities, that will be shared among teachers through an Internet clearinghouse.¹ These materials can also be incorporated into interdisciplinary courses, thus ensuring the retention of range-specific knowledge in integrated natural resource curricula (McClaran 2000).

Consideration must also be given to changing course formats to meet the diverse needs and abilities of today's students (Taylor 2003). Technology has created opportunities well beyond the traditional on-campus class schedule, such as interstate educational consortia of range faculty and students in online collaborative courses, workshop-style courses, on-demand training modules, and hybrids of online and field-based courses. These approaches can also accommodate integration of continuing education curriculum within university settings (McClaran 2000). The newer formats could enhance students' learning experiences by exposing them to a diverse array of concepts, viewpoints, and subject-matter experts and simultaneously address institutional and pedagogical limitations related to small class sizes (Surber and Porter 1999). However, implementing innovative course formats and programs involving cross-institutional collaboration requires dedicated effort on the part of faculty and administrators to overcome logistical roadblocks. Reconciliation of concerns about curriculum structure, institutional and administrative policies concerning tuition, and awarding academic credit represent formidable challenges to creating successful, multi-institutional partnerships (Anderson et al. 2008). Successful collaborative programs such as ACCEPtS (Evans et al. 2011), AG*IDEA, and Great Plains IDEA (Moxley et al. 2010) may serve as models that can be adapted and expanded to realize goals that are mutually beneficial to academic programs and institutions while serving the needs of students and the rangeland profession.

Adjusting Standards to Reconcile Modern Professional Needs

The current range curricula offered by US colleges and universities were developed in the 1970s, were adopted as the standard by OPM, and remain fundamental to accreditation by the SRM. These standards are inadequate in the modern context of rangeland management. For example, they do not incorporate technological advances and knowledge of natural resource laws and policies, and they do not provide adequate exposure to the global scale of rangeland management. Furthermore, the inflexible "course list" approach does not accommodate alternative curricular structures that sufficiently prepare students but simply differ in terms of delivery. Institutions of higher education and the rangeland profession need to strategically examine and define learning outcomes necessary to establish the foundation for forward-looking range education programs and work with SRM and OPM to modernize their standards. RSEC is launching an inclusive effort to draft a "core set" of specific learning outcomes and assessment measures that would pertain to all range programs

¹<http://www.rangelands.org/RSEC/RSEC.htm>

with an “elective set” of specific learning outcomes and assessments that are tailored to meet specialized needs according to region or landownership.

Strengthening the Range Profession Identity

A fundamental strength of rangeland management is that it is a science-based discipline that comprehensively and holistically addresses terrestrial ecosystems, their management, and an appreciation of the role of humans on the landscape. Some claim that our profession’s traditional ties to livestock production obscure the true land management nature of our discipline (Malechek and Call 1999; Schacht and McInnis 2003). Examples abound where positions that would be effectively filled by candidates with strong backgrounds in rangeland ecology and management are filled by applicants with more general science backgrounds. This practice may simply be a result of an inadequate supply of range-trained candidates. Students in biology, environmental science, geology, and geography courses are learning basic field skills at nearly every institution of higher learning, yet fewer than 50 academic institutions teach core range courses nationwide. It is also likely that potential employers are not actively choosing rangeland professionals because they are not familiar with the specific knowledge and skills that rangeland educated candidates can bring to land management. Focused recruitment efforts, such as the Web-based recruitment site for range education programs currently being developed by RSEC members, will help by showcasing career opportunities and characteristics of the profession.

We need to elevate the visibility and relevance of the range profession in today’s society, and this requires campaigning at multiple levels to increase society’s appreciation of rangelands and understanding of range science and management (Kreuter 2001; Edinger-Marshall and Perry 2011). Perhaps we should follow the lead of our colleagues in the Soil Science Society of America who have built on the momentum of the 2008 Smithsonian “Dig It: The Secrets of Soil” exhibit. Megonigal et al. (2009) estimated that 2 million visitors saw this exhibit in the summer of 2009, and the accompanying Web site had 4.3 million hits over a 15-mo period. This outreach effort and numerous popular press books and articles have increased visibility of soil science in society.

MANAGEMENT IMPLICATIONS

Range science education is facing multiple challenges as we turn the corner into the second century of range science and management. The reality is that we are confronting a diminished capacity to replenish the world with well-trained rangeland professionals at a time when many agree that sustainable management of the world’s rangelands is essential for global stability. We will be able to meet this challenge through perseverance, creativity, and collaboration of a diverse, dedicated group of rangeland educators and professionals. Efforts to identify emerging issues and articulation of the core competencies *unique* to rangeland management will strengthen our profession. Creative and timely solutions in educational delivery will enable shrinking range education programs to serve their students’ needs and produce well-trained graduates

essential to the future of the profession. The RSEC is dedicated to facilitating the redefinition and restructuring of educational and employment standards that are mutually beneficial to land management agencies and academic institutions. We encourage all who are concerned about the future of range education to vigorously engage in conversations and brainstorming about innovative approaches and strategies to ensure that we continually propel our profession forward and serve society’s needs for wise and sustainable stewardship of rangelands.

ACKNOWLEDGMENTS

We thank Chris Call, Mel George, Karen Hickman, Patricia Johnson, John Taylor, and other Range Science Education Council representatives for many spirited discussions about transforming rangeland science education that provided the inspiration for this manuscript. We would also like to thank two anonymous reviewers for insightful comments and suggestions that improved the article.

LITERATURE CITED

- ANDERSON, D., V. MOXLEY, S. MAES, AND D. REINERT. 2008. Multi-institution academic programs: dealmakers and dealbreakers. *Continuing Higher Education Review* 72:103–119.
- Box, T. 2001. Range management’s record. *Rangelands* 23(5):27–29.
- Box, T. W. 1964. Trends in range management education. *Journal of Range Management* 17:237–241.
- [BLS] BUREAU OF LABOR STATISTICS. 2009. Occupational outlook handbook, 2010–11 edition. Available at: <http://www.bls.gov/oco/ocos048.htm>. Accessed 18 September 2012.
- COWLING, R. M., B. EGOH, A. T. KNIGHT, P. J. O’FARRELL, B. REYERS, M. ROUGET, D. J. ROUX, A. WELZ, AND A. WILHELM-RECHMAN. 2008. An operational model for mainstreaming ecosystem services for implementation. *Proceedings of the National Academy of Science* 105:9483–9488.
- EDINGER-MARSHALL, S., AND L. PERRY. 2011. Recruiting diverse range students for the 21st century. In: Abstracts of the 64th Annual Meeting of the Society for Range Management; 6–11 February 2011; Billings, MT, USA. Wheat Ridge, CO, USA: Society for Range Management. Abstract 346.
- EVANS, M. R., R. HARKESS, J. KEUHNY, AND J. COLE. 2011. ACCEPtS: an alliance for cooperative course sharing in the plant sciences. *HortTechnology* 21:696–697.
- HEADY, H. F. 1961. Range curricula. *Journal of Range Management* 14:301–314.
- HEADY, H. F. 1999. Perspectives on rangeland ecology and management. *Rangelands* 21(5):23–33.
- HEINZ CENTER. 2008. State of the nation’s ecosystems 2008: measuring the lands, waters, and living resources of the United States. Available at: http://www.heinzctr.org/Major_Reports_files/The%20State%20of%20the%20Nation’s%20Ecosystems%202008.pdf. Accessed 18 September 2012.
- KIENAST, C. R., AND C. J. SCIFRES. 1973. Survey of professional attitudes toward range science education and training. *Journal of Range Management* 26:161–164.
- KNIGHT, R. W. 1999. Future changes in range management education. In: D. Eldridge and D. Freudenberger [EDS.]. People and rangelands—building the future. *Proceedings of the VI International Rangeland Congress* 1:369–372.
- KREUTER, U. 2001. Preparing for the future of range science. *Rangelands* 23(5):24–26.
- KREUTER, U. P., AND M. P. SCHELLENBERG. 2001. Charting our changing course. *Rangelands* 23(5):22–23.
- LEHMAN, A. 1964. A technical education isn’t enough. *Journal of Range Management* 19:171–172.
- LOPEZ, R. R., A. LOPEZ, R. N. WILKINS, C. C. TORRES, R. VALDEZ, J. G. TEER, AND G. BOWSER. 2005. Changing Hispanic demographics: challenges in natural resource management. *Wildlife Society Bulletin* 33:553–564.
- MACZKO, K., AND L. HIDINGER. 2008. Sustainable rangelands ecosystem goods and services. SRR Monograph No. 3: Sustainable Rangelands Roundtable. Available

- at: <http://sustainable.rangelands.warner.cnr.colostate.edu>. Accessed 18 September 2012.
- MALECHEK, J. C. 1992. Administrative considerations in range education. *Rangelands* 14:142–144.
- MALECHEK, J. C., AND C. A. CALL. 1999. A flexible curriculum for university study in rangeland resources. In: D. Eldridge and D. Freudenberger [EDS.]. *People and rangelands—building the future. Proceedings of the VI International Rangeland Congress* 1:364–365.
- MATTER, W. J., AND R. J. STEIDL. 2000. University undergraduate curricula in wildlife: beyond 2000. *Wildlife Society Bulletin* 28:503–507.
- MCCCLARAN, M. P. 2000. History of the range curriculum: are there new trails? *Rangelands* 22(6):23–27.
- MEGONIGAL, J. P., B. STAUFFER, S. STARRS, A. PEKARIK, P. DROHAN, AND J. HAVLIN. 2009. “Dig it!”: how an exhibit breathed life into soils education. *Soil Science Society of America Journal* 74:706–716.
- MILLENBAH, K. F., AND B. H. K. WOLTER. 2009. The changing face of natural resources students, education, and the profession. *Journal of Wildlife Management* 73:573–579.
- MOXLEY, V., S. MAES, AND D. ANDERSON. 2010. Great Plains interactive distance education alliance (Great Plains IDEA). In: D. Gearhart [ED.]. *Cases on distance delivery and learning outcomes: emerging trends and programs*. Hershey, PA, USA: Information Science Reference. p. 110–130.
- NICHOLSON, R. 1992. Undergraduate education. *Rangelands* 14:134–136.
- [NCES] NATIONAL CENTER FOR EDUCATION STATISTICS. 2008. Bachelor’s, master’s, and doctor’s degrees conferred by degree-granting institutions, by sex of student and discipline division: 2006–07. Available at: http://nces.ed.gov/programs/digest/d08/tables/dt08_275.asp. Accessed 18 September 2012.
- NORTON, B. E., AND J. N. EASTMOND, JR. 1981. Guiding a range curriculum with an educational needs assessment. *Journal of Range Management* 34:475–479.
- [NRC] NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES. 2009. *Transforming agricultural education for a changing world*. Washington, DC, USA: National Academies Press. 220 p. Available at: <http://books.nap.edu/catalog/12602.html>. Accessed 18 September 2012.
- [OPM] OFFICE OF PERSONNEL MANAGEMENT. 2008. An analysis of federal employee retirement data. Available at: http://www.opm.gov/feddata/RetirementPaperFinal_v4.pdf. Accessed 18 September 2012.
- OPM. 2009. GS-454 Rangeland management series. Available at: <http://www.opm.gov/qualifications/standards/IORs/g0400/0454.htm>. Accessed 18 September 2012.
- [RSEC] RANGE SCIENCE EDUCATION COUNCIL. 2000. Range Science Education Council constitution and by-laws. Available at: http://www.rangelands.org/RSEC/History/RSEC_Constitution_By-Laws_2000.pdf. Accessed 2 October 2012.
- SCHACHT, W. H., AND M. L. MCINNIS. 2003. Status of undergraduate education in range science in the USA. *Journal of Natural Resources and Life Sciences Education* 32:57–60.
- SHERWOOD, J. E. 2004. The role of the land-grant institution in the 21st century. Berkeley, CA, USA: Center for Studies in Higher Education, University of California, Berkeley. Research and Occasional Paper Series CSHE 6.04. Available at: <http://cshe.berkeley.edu/publications/docs/ROP.Sherwood.6.04.pdf>. Accessed 18 September 2012.
- SMITH, A. D. 1952. What should the goal of range education be? *Journal of Range Management* 5:304–305.
- SOWELL, B. 1997. What professional and technical skills will tomorrow’s range managers need? *Rangelands* 19(1):21–22.
- [SRM] SOCIETY FOR RANGE MANAGEMENT. 2009. University accreditation program handbook—approved January 2009. Available at: http://www.rangelands.org/pdf/accred_handbook_rev_1-09.pdf. Accessed 18 September 2012.
- SRM. 2011. Universities and colleges. Available at: http://www.rangelands.org/education_universities.shtml. Accessed 18 September 2012.
- SURBER, G., AND S. PORTER. 1999. Grass roots range management education with a high-tech twist. In: D. Eldridge and D. Freudenberger [EDS.]. *People and rangelands—building the future. Proceedings of the VI International Rangeland Congress* 1:358–362.
- TAYLOR, J. A. 2003. Building capacity in Australia’s rangelands. In: N. Allsopp, A. R. Palmer, S. J. Milton, K. P. Kirkman, G. I. H. Kerley, C. R. Hurt, and C. J. Brown [EDS.]. *Proceedings of the VIth International Rangeland Congress; 26 July–1 August; Durban, South Africa*. Durban, South Africa: International Rangeland Congress. p. 1801–1808.
- THUROW, T. L., M. M. KOTHMANN, J. A. TANAKA, AND J. P. DOBROWOLSKI. 2007. Which direction is forward: perspectives on rangeland science curricula. *Rangelands* 29(6):40–51.